I Can See Clearly Now

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Research Highlight

A mathematical tweak dramatically improves air pollution detection on cloudy days. Scientists at Pacific Northwest National Laboratory have devised a way to reduce cloud-induced glare by as much as ten-fold in some cases when satellites measure atmospheric pollution on cloudy days. Satellites monitor the pollution level in the atmosphere by measuring the amount of reflected sunlight. But sunlight bouncing off clouds and tiny particles of air pollution "blinds" instruments trying to determine how much the sky is actually reflecting. Researchers discovered that combining measurements of reflected light at several wavelengths can eliminate the cloud effects, making air pollution measurements much more accurate. The research was reported in the March 28 issue of Geophysical Research Letters.

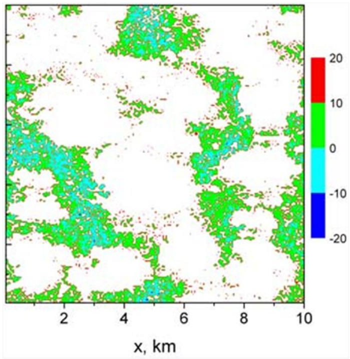
More accurate estimates of how much sunlight penetrates through air pollution can help reduce uncertainties and improve predictive models of climate change and its impacts.

Nearby clouds can increase the brightness of skies by 10 to 15 percent, overestimating the amount of air pollution by 140 percent. This appears counterintuitive at first glance: How can clouds make the sky look brighter? And why would satellite measurements interpret brighter skies as more polluted than dimmer ones? The reason is that clouds bounce sunlight around, making tiny particles of air pollution seem brighter than they really are. This, in turn, makes the particles reflect more sunlight, "fooling" satellites into thinking the atmosphere is more polluted than it really is.

To address this problem, Dr. Evgueni Kassianov and Dr. Mikhail Ovtchinnikov took advantage of the fact that clouds largely reflect the same amount of light regardless of its wavelength. Air pollution particles, on the other hand, reflect sunlight at different wavelengths to differing degrees. So, the researchers tested whether using ratios of sunlight reflectance at different wavelengths might allow the extra reflectance from clouds to drop out of their atmospheric images.

The idea worked. Using powerful computers at the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility at PNNL, the researchers constructed two images of a patch of cloudy sky using complex computational methods that can subtract the estimated cloud-induced glare. One method was based on total reflected light, and the other was based on ratios of how much light was reflected at two different wavelengths. The ratio image provided a view of the cloudy sky with much better contrast than the reflected light method, indicating that ratios better delineate clear sky from clouds.

The team then devised an innovative way to convert the ratios back into the aerosol optical depths, meaning how far light can penetrate the air when



This figure represents part of the sky with clouds, shadows, and the clear sky area around them. The image compares visibility (aerosol optical depth) data from two sources: calculated using the new method and original data. The comparison shows only a ten percent difference between the two sources. This shows that the new approach can improve substantially the ability to estimate how much sunlight is being reflected back to the atmosphere where clouds are present.

atmospheric pollution is present. The team created a database that related wavelength ratios, particle sizes, number of particles, and aerosol optical depth. From this database, two ratios would allow them to determine their aerosol properties of interest.

Next, the scientists needed to see how accurate their method was when compared with real data. They selected data from a typical summer day in the Southern Great Plains, gathered via the Atmospheric Radiation Measurement Program's Climate Research Facility in Oklahoma. They applied the ratio method to obtain the aerosol optical depth at three wavelengths and compared this to the original data. To the team's excitement, the ratio method estimated aerosol optical depth under partly cloudy conditions within ten percent accuracy, versus the more typical method that overestimates up to 140 percent.

The team plans more testing to further validate the method, by comparing the results with additional measurements taken during two ARM Program field campaigns in 2007. If the results hold up, the new approach may be applied to data being collected by the National Aeronautics and Space Administration's Earth Observing System, a web of satellites for long-term global observations of land, atmosphere, and oceans.

Reference(s)

Kassianov EI and M Ovtchinnikov. 2008. "On reflectance ratios and aerosol optical depth retrieval in the presence of cumulus clouds." Geophysical Research Letters, 35, doi:10.1029/2008GL033231.

Working Group(s)

Cloud Properties